Sun ELECTRIC CORPORATION

VOLT AMPERE TESTER

SUN VAT-40

Operator's Manual

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Figure 1—Volt Ampere Tester Model VAT-40.

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GENERAL INFORMATION

METER MECHANICAL ZERO ADJUSTMENT

Before connecting tester to vehicle, always check the mechanical zero of each meter. If needed, rotate ZERO ADJUST button as required to bring meter pointer to zero. See Figure 1.

AMMETER ELECTRICAL ZERO ADJUSTMENT

This adjustment knob is used to periodically set the ammeter pointer to the zero (0) line electronically. When adjusting zero, the TEST SELECTOR **must** be set to #2 CHARGING position with the Load Leads connected to the battery (Figure 1).

AMMETER

The Ammeter is a three-scale zero center meter, containing a 0-100 scale, a 0-500 scale and a diode stator scale. The diode stator scale contains a Blue area for an "OK" indication and a Red area for a "BAD" indication (Figure 1).

The **100-0-100** ampere range is used to measure ignition and accessory current loads up to 100 amperes, and to measure charging system outputs up to 100 amperes. To use this scale, set the TEST SELECTOR in the CHARGING position.

The **500-0-500** ampere range is used to measure battery loads (6 or 12 volt batteries), starter current draw up to 500 amperes and charging system output over 100 amperes. To use this scale, set the TEST SELECTOR in the STARTING position.

AMMETER POLARITY

The Ammeter is marked with plus (+) sign on the right side and minus (-) sign on the left. These marks can be used if desired to determine whether the battery is being charged or discharged as explained under Clamp-On Ammeter Pickup.

VOLTMETER

0-18 Volt Scale

This scale range is used to measure the voltage applied to the Load Lead clamps in the INT 0-18 volt setting. This scale can also be used with the Red and Black external voltmeter leads. (See voltmeter in Figure 1.)

-0.2 to +3.0 Volt Scale

This scale range is used with the Red and Black external voltmeter leads to measure battery cell voltage and to make Voltage Drop tests of electrical circuits.

VOLT SELECTOR

The VOLT SELECTOR (Figure 1) is set in the INT 18 V position for all area tests. In this position, the voltmeter is internally connected to the load cables and then to the battery through special wires within the load leads. This eliminates two test connections.

When the VOLT SELECTOR is set to the EXT 18 V position or the EXT 3 V position, the voltmeter is connected to the external Red and Black voltmeter leads.

FIELD SELECTOR

This three position toggle switch (Figure 1) is used in conjunction with the Blue Field Lead. It has a spring loaded off position. Its upper and lower positions are identified "A" and "B" respectively.

In the "A" position — The Blue lead is internally connected to the negative battery cable for testing A circuit, negative ground alternators and generators.

In the "B" position — The Blue lead is internally connected to the positive battery cable for testing B circuit, negative ground alternators and generators.

LOAD INCREASE CONTROL KNOB

The LOAD INCREASE control knob (Figure 1) is used to load 6 or 12 volt batteries. Loads up to 500 amperes can be applied with a duty cycle of 15 seconds "LOAD ON" followed by a 60 second "LOAD OFF" to be observed. The LOAD INCREASE control is also used to apply manufacturer's specified loads in performing charging system tests and detailed tests.

CAUTION: Loads should only be applied to 6 or 12 volt batteries.

LOAD LIGHT

When the LOAD LIGHT (Figure 1) is "ON" it indicates a load is being applied. With the LOAD INCREASE control in the Off position, the LOAD LIGHT should be "OFF" indicating a "NO LOAD" condition.

NOTE: The LOAD LIGHT is a reminder to set the LOAD INCREASE control knob to the "OFF" position after completion of a test requiring a load.

TEST SELECTOR

All meter scales and the TEST SELECTOR positions are color related to provide rapid association between the TEST SELECTOR position and the appropriate meter scale which is to be read. See Figure 1.

Position —

#1 STARTING — Coded Red and Green, indicating the Red amp scale and the Green 18 volt scale are used for both battery and starter tests.

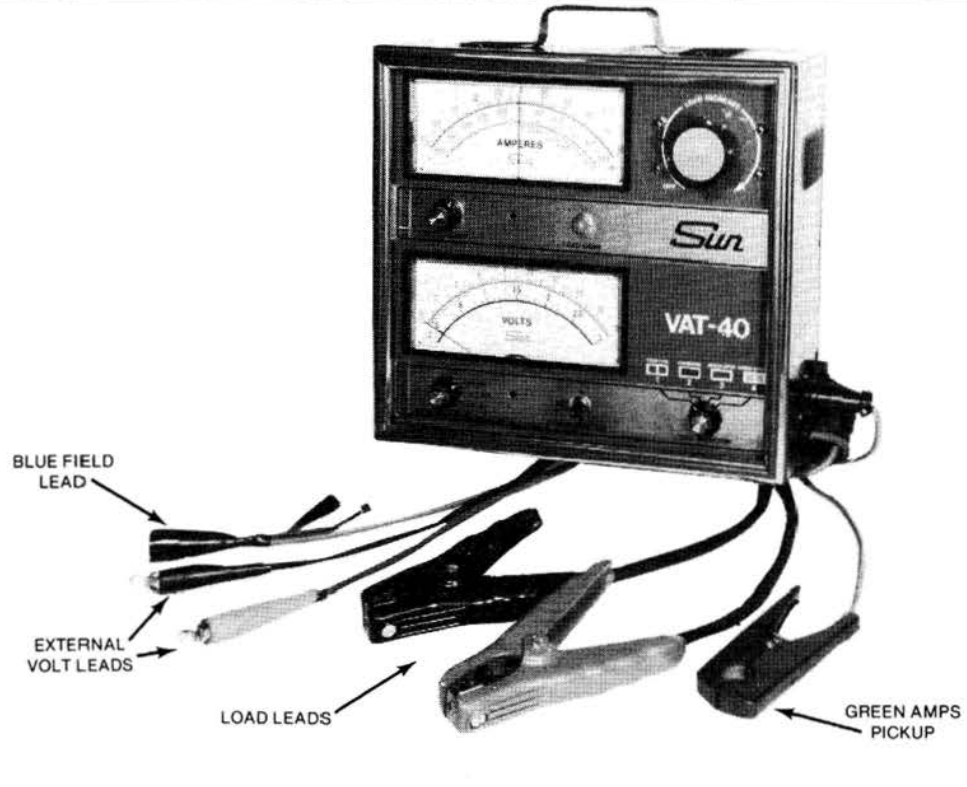
#2 CHARGING — Coded Blue, indicating the Blue 100 amp scale is used for most charging system output tests. This scale can also be used to measure current draw of any accessory and to measure battery drain.

#3 REGULATOR — Coded Green, indicating that the 18 volt scale is used for the testing of voltage regulator limit settings.

#4 DIODE STATOR — Coded in Red and Blue slashes, indicating the associated ammeter DIODE STATOR scale. Tester provides the circuits required to test diode and stator operating condition.

FIELD LEAD

The Blue Field Lead is used in place of the voltage regulator when it becomes necessary to bypass the regulator for making a charging system output test. This lead is equipped with the three commonly used connector types for convenient connections to alternator and generator field terminals. See Figure 2.



VAT-40 volts and ampere testing leads.

Figure 2

EXTERNAL VOLTMETER LEADS

This pair of Red and Black voltmeter leads (Figure 2) are used whenever voltage measurements other than battery terminal voltage are to be made. These leads are internally disconnected from the voltmeter any time the VOLT SELECTOR switch is in the INT 18 V position.

CLAMP-ON AMMETER PICKUP

The Green clamp-on Ammeter Pickup (Figure 2) senses the amount of current flowing in any wire by merely placing the clamp around the wire. Since the ammeter has a zero in the center of the scale, polarity need not be observed. For example, if the clamp-on Pickup is placed around either battery cable to the starter and the engine is cranked, the ammeter will indicate starter current draw. To use the arrow on the probe to indicate proper polarity, clamp the Green Amp Pickup around the negative battery cable with the arrow pointing **away** from the battery. When the ammeter needle is on the plus (+) side, the battery is charging.

A special circuit in the tester uses the clamp-on Ammeter Pickup to sense diode stator conditions, provided that at least 15 amps of current is flowing.

LOAD LEADS

The Load Leads (Figure 2) serve three purposes:

1. To load test a six or a twelve volt battery.
2. To provide power to operate the tester ammeter circuit.
3. To provide voltage readings when the VOLT SELECTOR is in the INT 18 V position.

The Load Leads are color coded Red for positive and Black for negative.

TESTER SUPPLY VOLTAGE

The accuracy of the ammeter circuit is maintained as long as the voltage available to the Load Leads is 4.5 volts or more. Should the applied voltage fall below 4.5 volts, the ammeter may read low.

CONDENSED TESTING PROCEDURE

GENERAL TEST CONDITIONS

This condensed testing procedure (which duplicates the Quick Reference Guide) will detect starting and charging problems, using manufacturer's specifications with the vehicle at normal operating temperature. Tests can be made under other conditions, but standard specifications will not apply. The general specifications shown here are for 12 volt systems. See Sun specification cards and manufacturer's specifications for more information.

CALIBRATION AND HOOKUP

All tests (except those requiring the use of the FIELD SELECTOR) can be made without disconnecting any vehicle leads because of the tester's clamp-on Ammeter Pickup. Ammeter readings will be accurate as long as the vehicle battery voltage is 4.5 volts or higher.

A. Check each meter's mechanical zero. Adjust if needed.

B. Rotate the LOAD INCREASE control fully counterclockwise to "OFF".

C. Connect the tester LOAD LEADS to the battery terminals; Red to positive, Black to negative.

D. Set the VOLT SELECTOR to "INT 18 V."

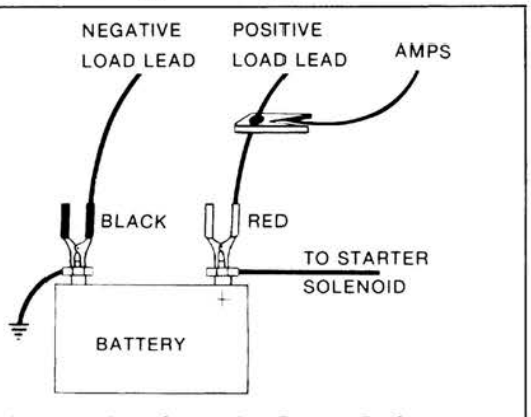
E. Set the TEST SELECTOR to #2 CHARGING position.

F. Adjust ammeter to read ZERO using the electrical ZERO ADJUST control.

TEST #1 STARTING

A. Battery Performance

1. Connect the Green clamp-on AMPS PICK-UP around either **tester** load cable (disregard polarity). See Figure 3.



Test lead connections for testing Battery Performance.

Figure 3

2. Set the TEST SELECTOR to the #1 STARTING position.

3. Observing the Red Ammeter scale, turn the LOAD INCREASE control clockwise until the ammeter reads 3 times the battery ampere hour rating, or ½ Cold Cranking Current at 0° F.

NOTE: If the test load cannot be reached and the battery voltage is below 9.6, the battery performance is poor. Perform Sun 3 Minute Battery Test, Sun #692-270.

4. Maintain load for 15 seconds and note Green Voltmeter scale reading. Then return LOAD CONTROL to off.

Test Indications:

a. Voltage with load applied is 10.0 or more, battery performance is GOOD. Battery is serviceable.

b. Voltage with load applied is 9.6 to 9.9, battery is serviceable, and Starting System Test can be performed. However, battery needs further testing. Perform Sun 3 Minute Battery Test.

c. Voltage with load applied is below 9.6 volts. Battery is either discharged or defective and further testing is needed. Perform Sun 3 Minute Battery Test.

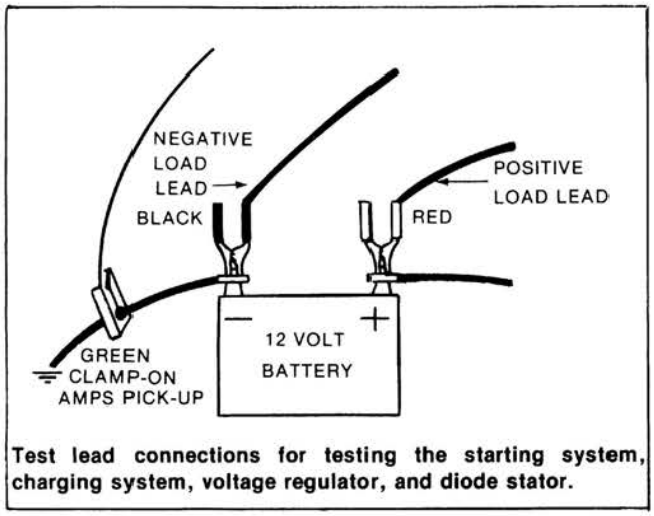
d. Test load cannot be reached. Perform Sun 3 Minute Battery Test.

B. Starting System

This test should be made only with a serviceable battery.

1. Turn off all lights and accessories and close all doors.

2. Connect the Green clamp-on AMPS PICK-UP around the **vehicle** ground battery cables. (Disregard polarity.) If more than one cable is connected to battery post, place clamp around all cables. See Figure 4.



Test lead connections for testing the starting system, charging system, voltage regulator, and diode stator.

Figure 4

3. Leave the TEST SELECTOR in the #1 STARTING position.

4. Prevent the engine from starting during the cranking test.

   a. Gasoline engines with externally mounted ignition coil: Remove the coil high tension lead at the distributor center tower and connect the disconnected lead to engine ground.

   b. Gasoline engines with integral mounted ignition coil: Disconnect the ignition switch lead from the ignition system assembly. Do not allow lead to touch ground.

5. Crank engine while observing Green Voltmeter reading and Red ammeter reading.

   Test Indications:

   a. Ammeter reading should not exceed maximum specified.

   b. Voltage should be at or above minimum specified.

   c. Cranking speed should be normal.

   NOTE: If no specification is available, a rule of thumb is:

   Starter current draw

   Large 8 cyl. engines—reading under 250 AMPS—OK

   Small 8 cyl. engines and 6 cyl. engines—reading under 200 AMPS—OK

   Cranking Voltage

   9.6 volts or higher—OK

   Experience and tests of good starting systems will provide the best test data when no specification is available.

   GOOD—Within manufacturer's specifications.

   BAD —Perform the voltage drop tests of cables and solenoid presented in the STARTING SYSTEM TESTING section to determine whether trouble is in the starter, cables, or solenoid.

6. Restore engine to starting condition.

TEST #2 CHARGING

A. Leave the Green clamp-on AMPS PICKUP around vehicle ground cable or cables. See Figure 4.

B. Set the TEST SELECTOR to the #2 CHARGING position.

C. Turn the ignition switch to the run position and read rate of discharge on the Ammeter.

D. Start engine and adjust speed to approximately 2000 rpm, or to manufacturer's specified test speed.

E. Adjust the LOAD INCREASE control slowly as required to obtain the highest reading on the Blue Ammeter scale. Do not drop voltage lower than 12 volts.

   NOTE: For charging systems rated above 100 amperes, use the #1 STARTING position and read the Red 0-500 amp scale.

F. Rotate LOAD INCREASE control to OFF.

G. Add the ammeter readings obtained in Steps C and E for total alternator output, and compare total to manufacturer's specification.

   GOOD—Alternator/Generator output within 10% of manufacturer's specification. Proceed to Test #3.

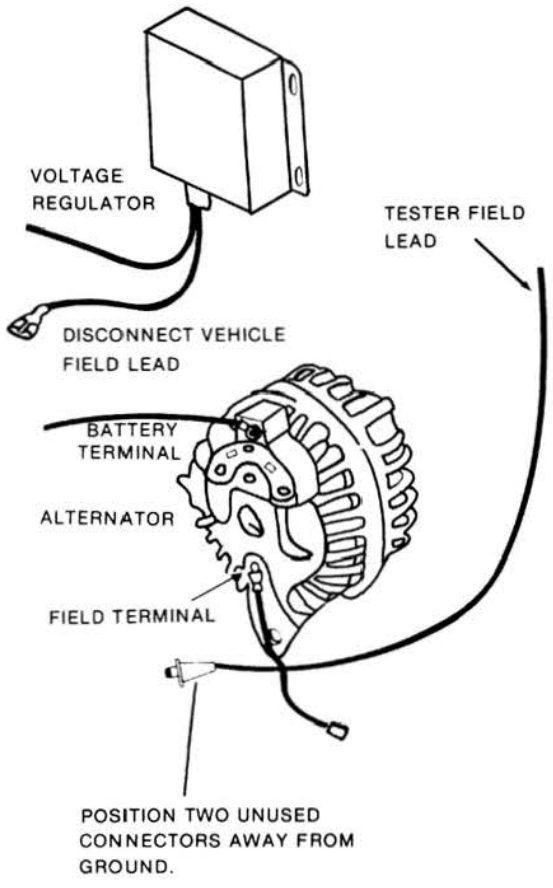
(Continued on next page)

BAD —Output not within 10% of specifications. Proceed to Test #2A "Output Test Using Tester FIELD SELECTOR".

TEST #2A OUTPUT TEST USING TESTER FIELD SELECTOR

NOTE: This test is to determine if alternator or voltage regulator is bad and is only required if system fails Charging Test #2. The test is for alternator charging systems only. Refer to the instructions for testing DC charging systems in the CHARGING SYSTEM TESTING Section.

A. Stop engine and **disconnect the vehicle lead from the alternator field terminal** (or disconnect the regulator connector plug if field terminal is inaccessible). See Figure 5.



Field lead connections for testing the alternator.

Figure 5

B. Select proper lead terminal and connect the Blue tester field lead to the alternator field terminal (or to the field lead in the regulator connector plug).

CAUTION: Never use Blue field lead with voltage regulator connected.

NOTE: Refer to "Special Alternator Test Information" card Sun #692-855 for identifying field terminal, and for instructions on bypassing regulators on Delcotron alternators with **internal** voltage regulators.

C. Set the TEST SELECTOR to the #2 CHARGING position for systems rated at less than 100 amperes, or to the #1 STARTING position for systems rated over 100 amperes.

D. Start engine and adjust the speed to the manufacturer's specified rpm.

E. Rotate the LOAD INCREASE control clockwise until the voltmeter indicates approximately 2 volts less than system voltage.

F. Hold the spring loaded FIELD SELECTOR in position A or B as indicated on the "Special Alternator Test Information" reference card.

NOTE: Positions reverse on positive ground systems. "A" becomes "B" and "B" becomes "A". However, no damage will occur if the wrong position is used. If it is unknown which system applies ("A" or "B"), test in each position.

G. Adjust the LOAD INCREASE control as required to obtain a reading on the voltmeter as specified by the manufacturer.

H. Observe the reading on the proper ammeter scale.

I. Release the FIELD SELECTOR switch, turn LOAD INCREASE control off and stop engine.

J. Add the ammeter reading observed in Step H to the reading observed in Step C under alternator/generator output Test #2, and compare total to manufacturer's specification.

GOOD—Output falls within 10% of manufacturer's specifications. Check vehicle wiring, replace **voltage regulator** and retest system.

BAD —Output does not fall within manufacturer's specifications. Replace or repair **alternator** per manufacturer's instructions and retest system.

TEST #3 VOLTAGE REGULATOR

A. Set the TEST SELECTOR to the #3 REGULATOR position (hookup as in Figure 4).

B. Operate engine at approximately 2000 rpm, or at the test speed specified by the manufacturer.

C. Note reading on Green Voltmeter scale after voltmeter reading ceases to rise, usually when current drops to 10 amps or less. (See manufacturer's specifications.)

GOOD—Voltage reading within manufacturer's specifications.

BAD —Voltage above or below specified voltage range. Replace voltage regulator and retest.

TEST #4 DIODE STATOR

A. Set engine to test speed; and with TEST SELECTOR set in the #3 REGULATOR position, adjust the LOAD INCREASE control if necessary to obtain a charge rate of at least 15 amperes (hookup as in Figure 4).

NOTE: If at least 15 amps was not obtained in in Test 2A, alternator is defective and should be replaced or repaired. Diode test is not valid.

B. Set the TEST SELECTOR to the #4 DIODE STATOR position, and observe the Red and Blue DIODE STATOR scale. Turn lead control OFF, return engine speed to idle, and stop engine.

GOOD—Meter reads in Blue area of DIODE STATOR scale.

BAD —Meter reads in Red area of DIODE STATOR scale. Replace or service alternator per manufacturer's instructions and then retest system.

TEST #5 CHARGING SYSTEM REQUIREMENTS

A. With engine stopped and TEST SELECTOR in #2 position (Figure 4), turn on all vehicle accessories, ignition switch, headlights at high beam, air conditioning, windshield wipers, rear window defroster if so equipped, etc.

B. Note reading on ammeter. This ammeter reads the total accessory load. Compare this reading to the total alternator output reading obtained in Test #2, Step G. Total alternator output reading should exceed accessory load reading by 5 amps or more.

STARTING SYSTEM TESTING

TESTING PRINCIPLES

The first step in testing the Starting System is to make a Battery Performance Test, since a good battery must be used to test the starter motor, cables and solenoid. With a known good battery, the starter motor, cables and starter solenoid can be checked by performing the Starting System Test.

Batteries need to be capable of cranking engines under all load conditions while maintaining enough voltage to supply ignition current for starting.

The generally accepted theory of battery testing is that a battery should maintain a voltage of 9.6 or more under starter load at normal operating temperature. Since starter loads vary and battery sizes vary, the Battery Performance Test is based on battery ratings provided by the manufacturer.

There are now two methods of rating batteries. For years batteries were rated in "Ampere Hours 20 Hour Rate." A new rating method called "Cold Cranking Current at 0° F" is gradually replacing the Ampere Hour rating. While some battery manufacturers are supplying both ratings, many are not. Therefore, **the method** of determining how much load to apply to test a battery depends on which rating is known.

1. Ampere Hour Rating.

   If the Ampere Hour rating is known, multiply this rating by **3** to obtain the load. For example, a 60 ampere battery multiplied by 3 equals a 180 ampere load.

2. Cold Cranking Current at 0° F.

   When using this rating, divide it by 2 to obtain the load. For example, a battery with a Cold Cranking Current rating of 400 divided by 2 equals a 200 amps load.

BATTERY PERFORMANCE LOAD TEST

In the Battery Performance Load Test the specified load is applied to the battery while observing the battery voltage.

A GOOD battery will maintain a voltage of 10 volts or more for at least 15 seconds (5 volts for 6 volt batteries).

A FAIR battery will read 9.6 to 9.9 volts (4.8 to 4.9 for 6 volt batteries). Batteries that test in this range can be used to perform starting system tests. However, these batteries should be completely tested (using Sun's 3 Minute Battery Test) to determine whether the battery is defective or merely needs charging. In this way, many batteries that are marginal will be detected and replaced, preventing a road failure. A load voltage of less than 9.6 volts (4.8 for 6 volt batteries) means that the battery is not serviceable in its present condition. This battery should also be completely tested to determine if it is defective and needs replacing or is merely in need of a recharge. Sun's Three Minute Battery Test is also used to test and evaluate this battery.

STARTING SYSTEM AREA TESTS

These tests should be made with a serviceable battery or the test results could be in error. The engine is cranked with the ignition system disabled so that the engine will not start.

The test procedure consists of cranking the engine for 10 seconds while observing the tester Red ammeter scale for starter current draw and the tester Green voltmeter scale for cranking voltage.

Good starting systems will read: Starter current is not to exceed the **maximum** specified for the vehicle being tested. Cranking voltage on 12 volt systems, some vehicles are rated at 9.6 volts minimum, some at 9.0 volts minimum. On 6 volt systems, 4.8 volts is the minimum. Refer to manufacturer's specifications.

Vehicles failing the Starting System Area Test need a pinpoint test of the cables and starter solenoid to determine whether the problem is in the cables, the solenoid, or the starter.

STARTING SYSTEM DETAILED TESTING

This section begins with the usual area testing of the battery and starting system, and then proceeds to the detailed tests which pinpoint component failure. The testing sequence is the normal one, demonstrating movement from the area testing of systems to the detailed testing of components. In normal testing situations, failures indicated in area testing point to the detailed tests that should be performed.

TESTER PREPARATION

Engine should be at normal operating temperature for **all** tests.

1. Rotate the LOAD INCREASE knob fully counterclockwise to OFF.
2. Check mechanical zero of meters. Reset if necessary using a small screwdriver.
3. Connect tester LOAD LEADS to battery terminals, Red to positive (+) Black to negative (-). Be sure that jaws connected to load leads make good contact with battery cable.
4. Set the VOLT SELECTOR to INT 18V. Tester voltmeter should indicate battery voltage.
5. Set the TEST SELECTOR to the #2 CHARGING position.
6. Adjust ammeter to read zero using tester ZERO ADJUST control knob.

BATTERY TEST

1. Connect the Green AMPS PICKUP around either **Tester Cable.**
   Disregard arrow indicating polarity (Figure 3).
2. Set the TEST SELECTOR to the #1 STARTING position.
3. Determine the test load of the battery **required** for the vehicle being tested.
4. As indicated by the color coded Starting Test, the Red 0-500 ammeter scale and the Green 0-18 volt scale will be used during this test. To test, turn the LOAD CONTROL knob clockwise and apply the required load. After the required load has been applied for 15 seconds, note the load voltage.

   NOTE: If the voltage drops to below 9.6 V for 12 volt batteries (4.8 V for 6 volt batteries) before the required load is reached, stop testing. The battery has failed this test.

Test Indications

a. Above 10 volts, battery performance is GOOD (5.0 V for 6 V batteries). Battery is serviceable.

b. Between 9.6 V and 9.9 V, battery performance is **Fair** (4.8 V—4.9 V for 6 volt battery). Battery is serviceable. See Sun 3 Minute Test.

c. Below 9.6 volts for a 12 volt battery and 4.8 volts for 6 volt battery, battery is **not serviceable**. See Sun 3 Minute Test.

STARTING SYSTEM TEST

NOTE: This test should be made only with a serviceable battery.

1. Connect the Green AMPS PICKUP around the vehicle ground cable or cables (Figure 4).
2. Make sure all lights and accessories are OFF and vehicle doors are closed.
3. Leave the TEST SELECTOR in the #1 STARTING position.
4. Prevent the engine from starting by either removing the ignition coil wire from the distributor cap or by removing the battery lead to the distributor (HEI). Be sure lead is clear of ground.
5. Crank engine with ignition key and note Red ammeter scale for cranking current reading and Green Voltmeter scale for cranking voltage reading.

   #### Test Indications

   GOOD—Cranking Current does not exceed maximum allowable by manufacturer and Cranking Voltage is at or above minimum specified by manufacturer.

   BAD —Not within specifications, needs further testing of components.

6. Restore engine to starting condition.

INSULATED CIRCUIT RESISTANCE TEST

Excessive resistance in the starting system circuitry (wiring or frame connections) can cause slow cranking speed and hard starting.

The starting system's main electrical circuit is generally a series circuit from the battery insulated post, to a starter solenoid, to the starter motor, to ground (chassis) and return to the battery ground post. The solenoid is controlled or

operated by the ignition switch. This solenoid circuit frequently contains a safety switch such as the transmission "Neutral switch."

The starting system will function properly only when these circuits and electrical components are in satisfactory condition. Corrosion, loose terminals, damaged or undersized cables will cause cranking problems. In addition, the switches involved must make good electrical connections when closed.

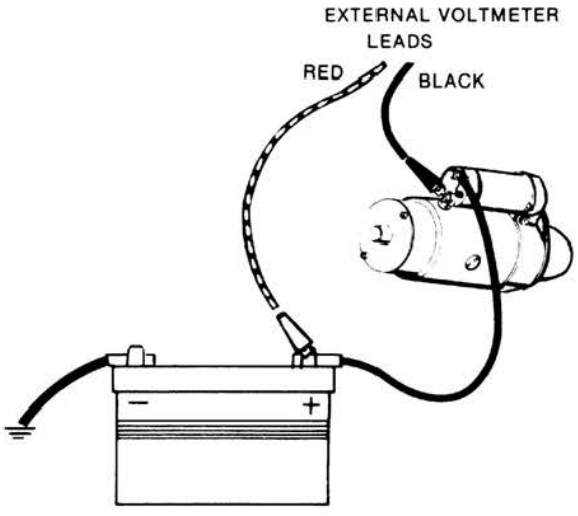
Test Procedure

Voltage drops are measured by connecting a voltmeter in parallel (across) the circuit section under test and then reading the voltmeter while the circuit under test is in operation.

Test is of voltage drop from battery to starter (insulated circuit).

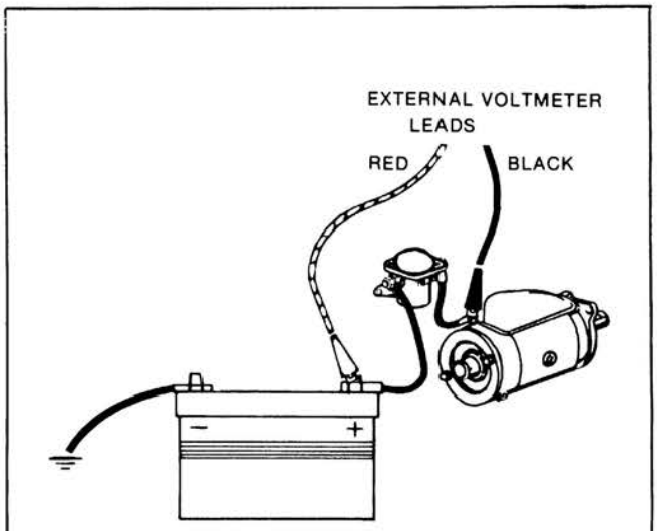
A. Set the VOLT SELECTOR to EXT 3 V position.

B. Connect test leads as shown in Figures 6 and 7 for type of circuit being tested. Observe polarity.



External voltmeter lead connections where starter solenoid is on the starter.

Figure 6



External voltmeter lead connections where starter solenoid is between battery and starter.

Figure 7

NOTE: Voltmeter should read off scale to right until engine is cranked. If meter reads to the left of zero, reverse volt leads.

C. Disconnect lead from coil secondary (tower) to prevent engine from starting during test.

D. Crank engine and observe voltmeter reading while cranking. Reading should be within manufacturer's specifications.

Test Indications

GOOD—Less than 0.4 volt (6 volt system)
Less than 0.5 volt (12 volt system)
go to Ground Circuit Resistance Test.

BAD —More than 0.4 volt (6 volt system)
More than 0.5 volt (12 volt system)
indicates excessive voltage drop.

NOTE: To locate the cause of the excess voltage drop, move the EXT VOLT lead on the starter progressively toward the battery. With each move crank engine and read voltage. When a noticeable decrease in the voltage reading is observed, the trouble is located between that point and the preceding point tested. It will be either a damaged cable or poor connection, an undersized wire or possibly a bad contact assembly within the solenoid.

Values of maximum voltage drops for the cranking circuit are as follows:

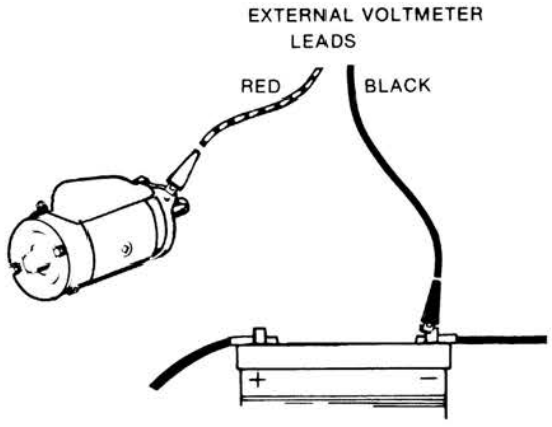
	6 VOLT	12 VOLT SYSTEM
Each Cable	0.1 volt	0.2 volt
Each Connection	0.0 volt	0.0 volt
Starter Solenoid Switch	0.3 volt	0.3 volt

GROUND CIRCUIT RESISTANCE TEST

Connect voltmeter across the ground circuit as follows and read voltage drop while cranking engine.

A. Set VOLT SELECTOR to EXT 3 V.

B. Observing polarity, connect volt leads to battery ground post and starter motor case (Figure 8). Scratch through paint with clip for good connection.



External voltmeter lead connections for starting ground circuit resistance test.

Figure 8

C. Crank engine and observe voltmeter reading while cranking. Reading should be within manufacturer's specifications.

Test Indications

GOOD—Less than 0.1 volt (6 volt system)
Less than 0.2 volt (12 volt system)
go to Solenoid Switch Circuit Resistance Test.

BAD —More than 0.1 volt (6 volt system)
More than 0.2 volt (12 volt system)
indicates the presence of a poor ground circuit connection. Could be a loose starter motor mounting bolt or a bad battery ground terminal post connector, or a damaged or under sized ground system wire from battery to engine block.

Isolate the cause of excess voltage drop in the same manner recommended in the Starter System Insulated Circuit Test.

SWITCH CIRCUIT RESISTANCE TEST

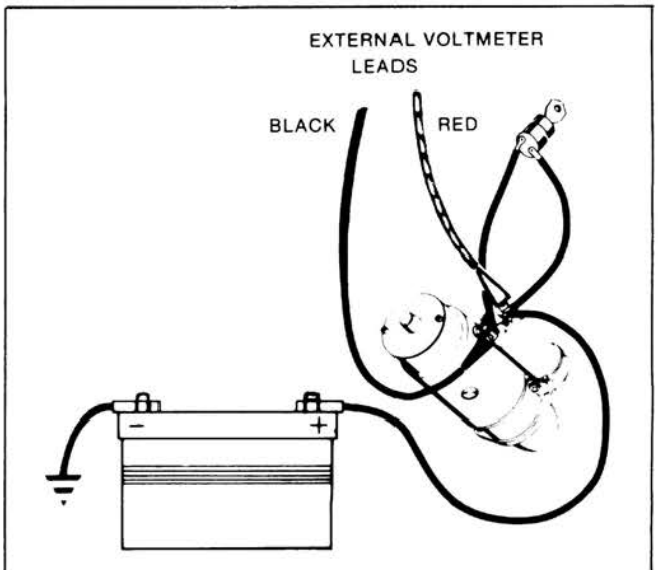
High resistance in the solenoid switch circuit will reduce the current flow through the solenoid windings which can cause improper functioning of the solenoid. In some cases of high resistance, it may not function at all. Improper functioning of the solenoid switch will generally result in burning of the solenoid switch contacts causing a high resistance in the starter motor circuit.

Test Procedure

Check vehicle wiring diagram if possible to identify the solenoid circuit components. These are usually the ignition switch, the automatic transmission neutral switch, and the starter solenoid winding. In some instances, a separate starter relay is also used, and the contacts in this starter relay should be checked for excessive resistance just as the solenoid switch is tested.

A. Set the VOLT SELECTOR to EXT 3 V position.

B. Observing polarity, connect volt leads to both solenoid switch terminals as shown in Figure 9.



External voltmeter lead connections for starting solenoid switch circuit resistance test.

Figure 9

Starting System Testing

NOTE: Voltmeter should read off scale to right until engine is cranked. If meter reads to left of zero, reverse volt leads.

C. Automatic transmission vehicles—place the transmission lever in neutral or park.

D. Crank engine using the vehicle's ignition switch.

OBSERVE voltmeter reading at this time.

Test Indications

(Unless otherwise specified)

GOOD—Less than 0.5 volt—indicates circuit condition good. If starter current draw was high or cranking speed slow, a faulty starter motor is indicated. In this case the motor should be removed for replacement or repair.

BAD —More than 0.5 volt—indicates excessive resistance. If voltmeter reads more than 0.5 volt, it is usually an indication of excessive resistance. However, on certain vehicles, experience may show that slightly more voltage loss is normal.

Isolate the point of high resistance by placing the voltmeter leads across each component of the circuit in turn, taking readings with the starter motor control switch operated. A reading of more than 0.1 volt across any one wire or switch is usually an indication of trouble.

NOTE: Neutral Safety Switch should be checked for voltage drop.

If high readings are obtained across the neutral safety switch used with automatic transmissions, check the adjustment of the switch as outlined in the manufacturer's shop manual.

CHARGING SYSTEM TESTING

TESTING PRINCIPLES

The main function of the charging system is to produce all of the electrical power required by the vehicle electrical system. While the engine is being operated at a reasonable speed above idle, the output of the charging system is used directly to operate the ignition system, lights, radio, and all other electrical accessories. In addition, under these operating conditions the charging system output must be sufficient to maintain the battery in a full state of charge.

In the design of the vehicle, each manufacturer determines the total electrical requirements of the vehicle and then selects a generator or alternator of sufficient capacity to handle the load. The vehicle's axle ratio is also taken into consideration when determining the charging unit drive belt ratio. Thus, the specified charging system output and the test speed may vary somewhat from one make of vehicle to another.

Another important consideration in charging system operation is the level at which the charging system voltage is limited. If the voltage is limited at too low a level, it is impossible to maintain the vehicle's battery at a full state of charge. On the other hand, if too high a limit is selected, battery overcharge, excessive light flare, and short electrical accessory life will result.

As charging system outputs may vary from make to make, the voltage limiter (regulator) specifications can also vary. Each manufacturer will specify a voltage limiter operating range best suited for each specific vehicle. Voltage limiter operating specifications may vary depending upon circuit length and design and specified operating temperature. For example, 1975 passenger cars call for settings as low as 13.4 to 14.4 volts on some GM products to as high as 14.3 to 15.8 on the Dodge Colt.

Always compare test results with manufacturer's specifications before coming to conclusions regarding the performance or efficiency of charging systems and their components.

ALTERNATOR TESTING

A characteristic of alternator type charging systems is that occasionally one will test almost to specification even though the unit contains an "open" diode.

The importance of detecting an "open" diode is that, in addition to the loss of several amperes of output, an open diode can lead to the failure of other diodes, resulting eventually in a dead battery. In addition, an open diode could cause a voltage regulator to fail. A replacement regulator would also fail if the open diode was not detected and corrected. To avoid the possibility of overlooking this type of defect, the test sequence recommended with the VAT-40 includes a Diode Stator test.

COMPLETE CHARGING SYSTEM TESTER

The VAT-40 is programmed to make all of the necessary tests of a charging system in the proper order. Since the battery is a part of the charging system, its condition must be considered when testing the alternator and voltage regulator. The condition of the battery determines how hard the alternator works and a bad battery can cause an alternator failure.

In addition, the condition of the starting system, or of the engine if it is hard to start, can cause a battery to be run down. Therefore, any test of the charging system should include a test of the battery and starting system.

The area test sequence is:

1. Battery and Starting System Test
2. Alternator Output Test
3. Voltage Regulator Test
4. Diode Stator Test

The Battery and Starting System Tests have been covered previously.

CHARGING SYSTEM DETAILED TESTING

This section presents a systematic method of testing the charging system. It starts with area tests of the system and then presents the detailed tests that would be used to locate the source of any failures that may be found during area testing.

TEST #2 CHARGING SYSTEM

The Alternator Output test is made with the Green clamp-on AMPS PICKUP clamped around the vehicle ground battery cables. Connected in this manner, the ammeter will not sense that portion of the charging system output used to operate the ignition system and instruments. Therefore, the ignition and accessory draw is measured first with the engine stopped. This is then added to the output reading to arrive at a true total charging system output value.

Charging System Testing

A. Set the TEST SELECTOR to the #2 CHARGING position (hookup as in Figure 4).

B. Set the ignition switch to the run position and read the amount of discharge on the ammeter. This reading represents the amount of current the alternator must supply for ignition and accessories that is not seen by the tester.

C. Start the engine and adjust the speed to approximately 2000 rpm, or to the manufacturer's specified test speed.

D. Adjust the LOAD INCREASE control as required to obtain the highest reading on the ammeter, but do not cause the voltage to drop lower than 12 volts.

NOTE: For charging systems rated above 100 amperes, use the #1 STARTING position and read the 500 ampere scale.

Applying a load causes the voltage regulator to stop regulating (limiting field current) and permits the alternator to produce its maximum output.

E. Rotate LOAD INCREASE control to OFF.

F. Add the ammeter readings obtained in Steps B and D, and compare total to manufacturer's specification.

GOOD—Alternator/Generator output within 10% of manufacturer's specifications. Proceed to voltage regulator test.

BAD —Output not within 10% of specifications; proceed to "Output Test using Tester Field Circuit."

TEST#2A OUTPUT TEST WITH FIELD SELECTOR

NOTE: This test is only required if system fails the #2 CHARGING output test. The procedure followed in making this test requires that the vehicle's regulator be eliminated from the circuit and field current be supplied through the tester's field lead and switch.

A. AC Charging Systems

1. Stop engine and disconnect the vehicle lead from the alternator field terminal or disconnect the regulator connector plug.
2. Select the proper lead terminal and connect the Blue tester field lead to the alternator field terminal. See Figure 5.

   NOTE: Refer to "Special Alternator Test Information" card for identifying field terminal, correct test position, and for instructions on bypassing regulators on Delcotrons with **internal** voltage regulators.

3. Set the TEST SELECTOR to the #2 CHARGING position for systems rated at less than 100 amperes, or to the #1 STARTING position for systems rated over 100 amperes.
4. Start the engine and adjust speed to the manufacturer's specified rpm.
5. Rotate the LOAD INCREASE control clockwise until the voltmeter indicates approximately 2 volts less than system voltage.
6. Hold the spring loaded FIELD SELECTOR in position A or B as indicated on the "Special Alternator Test Information" reference card.

NOTE: If charging system type is unknown, test in both "A" and "B" positions.

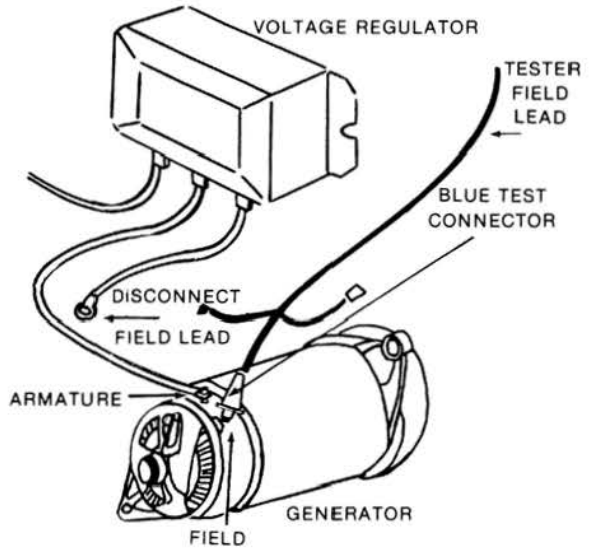
7. Adjust the LOAD INCREASE control as required to obtain a reading on the Voltmeter as specified by the manufacturer.
8. Observe reading on the Ammeter.
9. Release the FIELD SELECTOR switch, turn the LOAD INCREASE control to off and stop the engine.
10. Add the ammeter reading observed in Step 8 above to the reading observed in Step B under Output Test #2 and compare total to manufacturer's specification.

    GOOD—Output falls within 10% of manufacturer's specifications. If vehicle wiring is good, voltage regulator is BAD.

    BAD —Output does not reach manufacturer's specifications. Alternator is BAD.

B. DC Charging Systems

DC charging systems are tested the same as AC charging systems, but the test indications are different. See Figure 10 for hookup.



Field lead connections for testing the DC generator.

Figure 10

GOOD—Output equals or exceeds manufacturer's specifications. If vehicle wiring is good, the voltage regulator is bad.

BAD —Output does not reach manufacturer's specification or excessive arcing is noted at the commutator. Generator is BAD. If amperage is low and volt- is high, the cutout relay fails to close, or the regulator has a poor ground.

VOLTAGE REGULATOR TEST #3

A. Set the TEST SELECTOR to the #3 REGULATOR position (hookup as in Figure 4).

B. Operate the engine at a speed of 2000 rpm, or at the test speed specified by the manufacturer.

C. Note the reading on the voltmeter after it ceases to rise; generally the charging rate is between 5 and 10 amperes. The length of time required depends upon the battery state of charge.

GOOD—Voltage reading within manufacturer's specification.

BAD —Voltage above or below specified voltage range. Regulator needs replacing or adjusting.

DIODE STATOR TEST #4

A. With TEST SELECTOR set in the #3 REGULATOR position, adjust the LOAD INCREASE control if necessary to obtain a charge rate of at least 15 amperes (hookup as in Figure 4).

B. Set the TEST SELECTOR to the #4 DIODE STATOR position; observe the Red and Blue DIODE STATOR scale; then return the LOAD INCREASE control to OFF and the engine speed to idle.

C. Set the TEST SELECTOR to the #2 CHARGING position.

GOOD—Meter reads in Blue area of DIODE STATOR scale.

BAD —Meter reads in Red area of DIODE STATOR scale. Replace or service alternator per manufacturer's instructions and then retest system.

NOTE: Diodes can be tested if desired while bypassing the voltage regulator with the tester FIELD SELECTOR, provided that at least 15 amperes of charging current can be obtained. Alternators that cannot obtain at least 15 amperes with the regulator bypassed are bad and must be repaired or replaced. The diode test is not valid for these alternators.

CHARGING SYSTEM REQUIREMENTS TEST #5

As indicated earlier, the charging system output should be great enough to satisfy all the electrical requirements of the vehicle plus enough besides to be assured that the battery will be maintained in a state of full charge.

Occasionally you will encounter a vehicle in which electrical accessories have been added. Sometimes you will not be able to determine the rated output of the vehicle's alternator. To determine whether this charging system output is still

adequate to meet the requirements of the vehicle, perform the test outlined below:

A. With the Green clamp-on AMPS PICKUP connected as for charging system output test and the engine stopped set the TEST SELECTOR to the #2 CHARGING position (hookup as in Figure 4).

B. Turn on all vehicle accessories, ignition switch, headlamps on high beam, air conditioning, windshield wipers, rear window defroster, etc.

C. Observe the Ammeter reading.

This reading represents the total accessory load. Compare this reading with the output reading obtained in Test #2 CHARGING output. The total alternator output reading should exceed the total accessory load by 5 amps or more.

CIRCUIT RESISTANCE TEST

Circuit resistance tests are made to determine the amount of voltage loss occurring between the output terminal of the generator or alternator and the insulated battery post, and between the generator or alternator housing and the ground battery post respectively. Any voltage loss caused by high resistance in these circuits will reduce the overall charge rate and lead to eventual battery discharge.

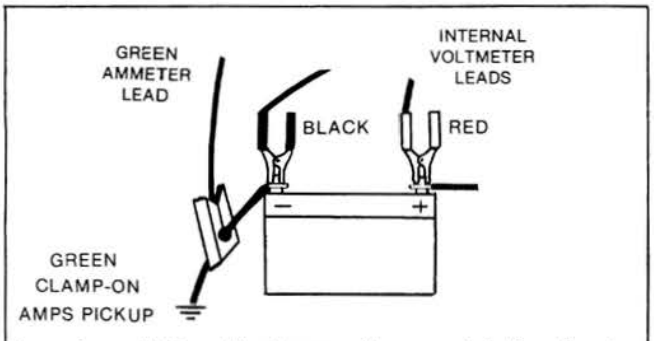
Test Procedure

A. Set TEST SELECTOR knob to #2 CHARGING position.

B. Set LOAD INCREASE knob to the OFF position.

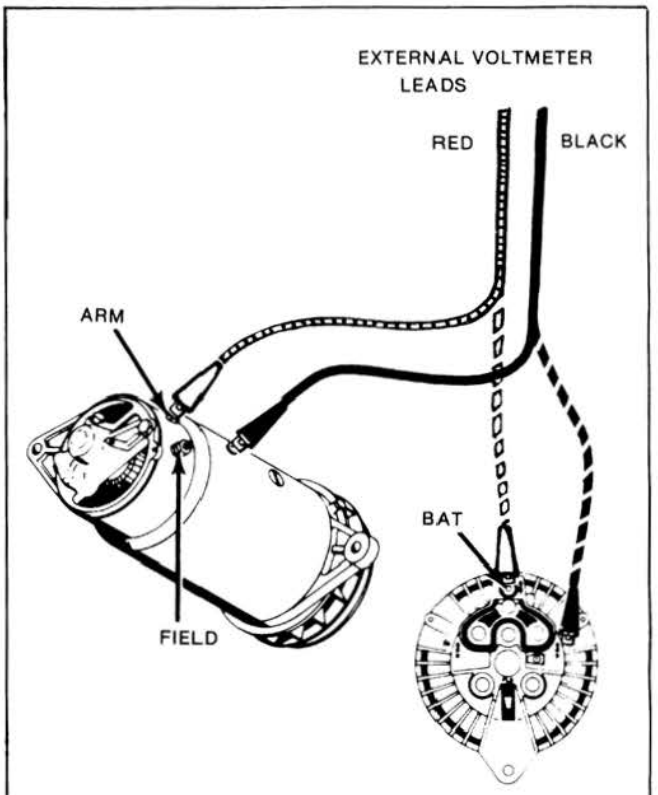
C. Set VOLT SELECTOR knob to the EXT 18 V position.

D. Connect tester leads as shown in Figures 11 and 12. Reverse voltmeter leads when testing vehicle with positive ground electrical systems.



Ammeter and internal lead connections used during charging system testing.

Figure 11



External voltmeter lead connections for charging circuit resistance test.

Figure 12

E. Start engine and adjust speed to approximately 2000 rpm.

F. Adjust LOAD INCREASE knob until the reading of the Blue Ammeter Scale indicates the test current specified by the manufacturer.

G. Observe the reading on the Green Voltmeter scale. Note this reading.

H. Set VOLT SELECTOR knob to INT 18 V position. Observe the reading on the Green Voltmeter scale. Subtract this reading from the reading obtained in Step G. This difference is the voltage drop caused by circuit resistance and must be within specifications for proper charging system operation.

Test Indications

GOOD—Voltage difference within specifications—indicates charging circuit good—perform Regulator Ground Circuit Resistance Test.

BAD —Exceeds specifications—conduct Charging System Insulated Circuit Resistance Test.

NOTE: The circuit resistance, as indicated by the above voltmeter reading, is equal to the total of both the Insulated Circuit and the Ground Circuit Voltage losses.

In general on alternator systems the following specifications apply:

American Motors	0.65 volt MAX.
Chrysler Motors	0.9 volt
Ford Motor Company	0.4 volt w/Ind Lamp
	0.8 volt w/Ammeter
General Motors	0.65 volts

INSULATED CIRCUIT RESISTANCE TEST

If voltage loss in the preceding test (System Circuit Resistance) exceeds the specified amount, an excessive resistance is present within the charging circuit. That is, within the wiring harness, connections, regulator and vehicle ammeter if used. The excessive resistance can take the form of LOOSE OR CORRODED CONNECTIONS at output terminal of generator or alternator, armature terminal of regulator, back of ammeter or battery terminal of the starter solenoid battery cable connections, faulty wiring from generator to regulator to ammeter or ammeter to starter solenoid, burned or oxidized cutout relay contacts, or poor electrical connections between the generator or alternator and the engine. To isolate the point of excessive resistance proceed with the following charging system resistance tests.

Test Procedure

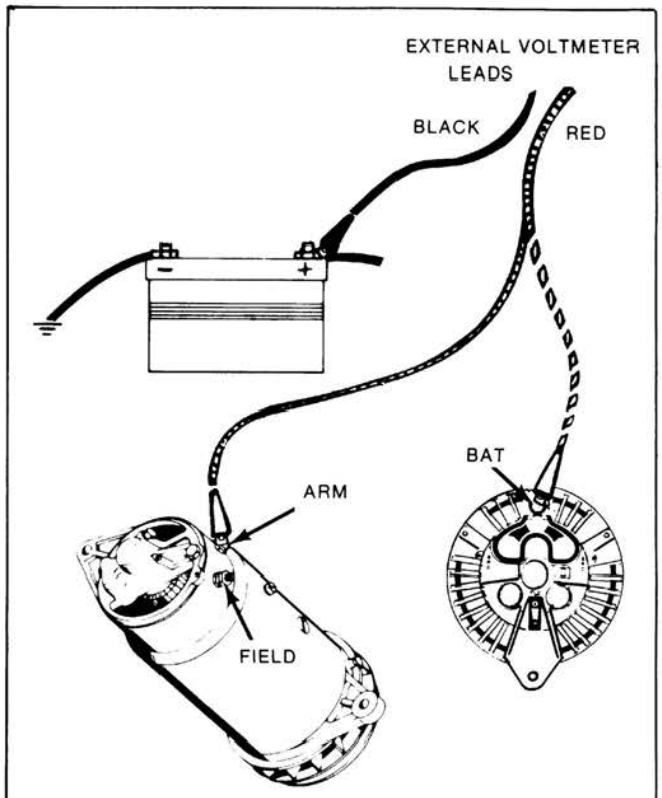
A. Set VOLT SELECTOR knob to EXT 3 V position.

B. Observing polarity, connect test leads as shown in Figures 11 and 13. Reverse voltmeter leads for positive ground systems.

C. Start engine and adjust speed to approximately 2000 rpm.

D. Adjust LOAD INCREASE knob until Blue Ammeter scale indicates the test current specified by the manufacturer.

E. Observe voltage reading on Black (3 volt) Voltmeter scale and compare with specifications.



External voltmeter lead connections for charging insulated circuit resistance test.

Figure 13

Test Indications

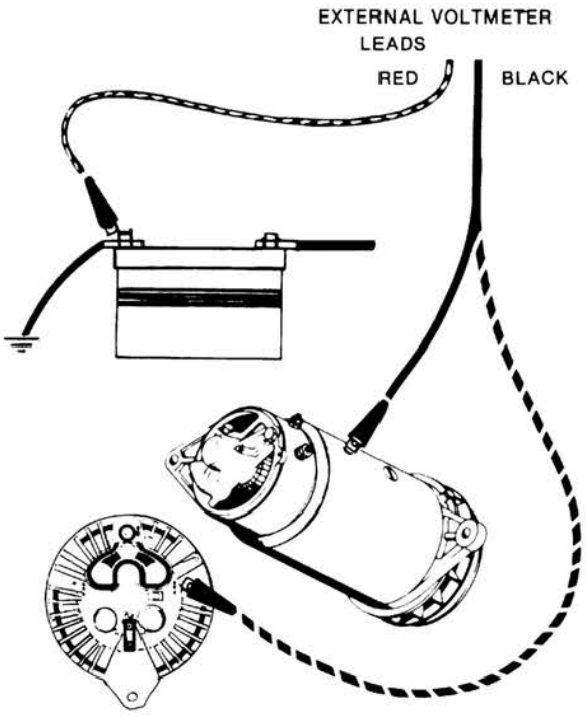
VOLTMETER READING:

GOOD—Within specifications — proceed to Ground Circuit Resistance Test.

BAD —Above specifications—indicates excessive circuit resistance. Repeat this test with voltmeter connected across each connection and each wire of insulated circuit. Compare reading with maximum connector and wire specifications to isolate the point of high resistance.

GROUND CIRCUIT RESISTANCE TEST

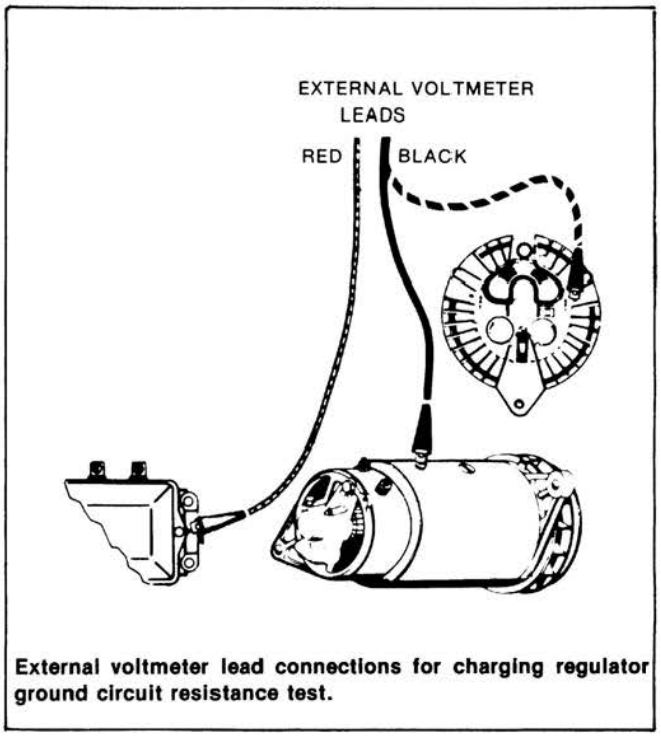
A. Observing polarity, connect test leads as shown in Figures 11 and 14. Reverse voltmeter leads for positive ground systems.



External voltmeter lead connections for charging ground circuit resistance test.

Figure 14

B. Observing polarity, connect test leads as shown in Figures 11 and 15. Reverse voltmeter leads for positive ground systems.



External voltmeter lead connections for charging regulator ground circuit resistance test.

Figure 15

B. Start engine and adjust speed to approximately 2000 rpm.

C. Adjust LOAD INCREASE knob until Blue Ammeter scale indicates the test current specified by the manufacturer.

D. Observe Black (3 volt) Voltmeter scale and compare with specifications.

Test Indication

GOOD—Within specifications—prceed to Regulator Ground Circuit Resistance Test.

BAD —Above specifications—repeat test with voltmeter leads connected across each connection and each wire of the ground circuit to isolate point of resistance.

REGULATOR GROUND CIRCUIT RESISTANCE TEST

A. Set Red VOLT SELECTOR knob to EXT 3 V.

C. Start engine and adjust speed to approximately 2000 rpm.

D. Adjust LOAD INCREASE knob until Blue Ammeter scale indicates the test current specified by the manufacturer.

E. Observe the reading on the Black (3 volt) Voltmeter scale. Compare with specifications.

Test Indications

GOOD—Within specifications—circuit good.

BAD —Above specifications—if voltmeter reading exceeds 0.1 volt, excessive resistance is present in the ground circuit between the regulator and generator or alternator. Check regulator ground system for loose mounting bolts or damaged ground strap.

NOTES

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NOTES

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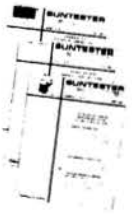

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